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(54) **ELECTRO MAGNETIC BALLAST FOR A GAS DISCHARGE LAMP**

ELEKTROMAGNETISCHES VORSCHALTGERÄT FÜR EINE GASENTLADUNGSLAMPE

BALLASTE ÉLECTROMAGNÉTIQUE POUR LAMPE À DÉCHARGE DE GAZ

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Description

FIELD OF THE INVENTION

[0001] The present invention relates in general to the switching of discharge lamps.

BACKGROUND OF THE INVENTION

[0002] It is generally known that gas discharge lamps, for example the well-known TL-lamps, are driven by an electro magnetic ballast (EM ballast). Figure 1 is a schematic block diagram, illustrating such conventional EM ballast 1 for a lamp 2. The ballast 1 of this example comprises an inductor L and a capacitor C in series with the lamp 2 to be driven, and a mechanical switch S in parallel to the lamp, typically of a bimetal design. The ballast 1 further has input terminals 3 for connection to mains, typically 230 V 50 Hz in Europe. Lamp connector terminals are indicated at 4, lamp electrodes are indicated at 5. In the case of such conventional ballast, the lamp can only be switched ON and OFF by switching the mains.

[0003] In a more sophisticated design, the mechanical switch is replaced by a controllable semiconductor switch, operated by an intelligent control device such as for instance a micro controller. Figure 2 is a schematic block diagram, illustrating such ballast 10, as for example illustrated by WO 03/103344. Compared to the example of figure 1, the mechanical switch S has been replaced by an electronic switching circuit 20. This electronic switching circuit 20 comprises a full-wave rectifier 21 (shown as a four-diode bridge) having input terminals 22, 23 connected in parallel to the lamp 2, and having a positive output terminal 24 and a negative output terminal 25. The electronic switching circuit 20 further comprises a semiconductor switch 26, shown as a MOSFET, connected between the positive and negative terminals 24, 25.

[0004] The electronic switching circuit 20 further comprises a control device 28, having a control output 28a connected to the control terminal of the switch 26. The control device 28 may derive its power from the terminals 24, 25, or may derive its power from an external circuit (not shown). The control device 28 may be responsive to external command signals, transmitted over an external circuit (not shown), via a wired or wireless link, e.g. RF.

[0005] Assume that the mains power is switched on while the switch 26 is OFF, i.e. non-conductive. The voltage from the mains is insufficient to start the lamp. Starting the lamp is done by the controller 28 in two steps. The first step involves switching the switch 26 ON, i.e. generating a control signal S_c for the switch 26 such as to render the switch 26 conductive. Now, an AC current will flow through the inductor L and the lamp electrodes 5, heating the lamp electrodes 5. In a second step, the controller 28 switches the switch 26 OFF again, i.e. it generates its control signal S_c for the switch 26 such as

to render the switch 26 non-conductive. As a result of this interruption, the inductor L develops a high voltage causing breakdown and ignition of the lamp, so that lamp current flows between the electrodes 5 within the lamp.

[0006] The magnitude of the ignition voltage induced by the inductor L depends on the amount of energy $E(L)$ stored in the inductor at the moment of interrupting the current circuit, which can be expressed as $E(L) = 0.5 \cdot L \cdot I^2$.

10 SUMMARY OF THE INVENTION

[0007] A problem is associated with the fact that the voltage induced by the inductor L is also applied to the switch 26, which is after all connected in parallel to the lamp 2. Normally, the lamp ignites before the induced voltage reaches its maximum, but it may be that the lamp does not ignite immediately. In such case, the maximum value of the induced voltage will be applied to the switch, that is not capable to resist this voltage and will conduct a current in avalanche mode. Such current may cause the switch to be destroyed. In order to prevent this, the controller 28 may be programmed to set the timing of the interruption of the preheat current so that it does not coincide with the maximum current: a suitable timing is for instance 86% of the current period. In that case, for an exemplary situation of a 70 W lamp, where the coil has an inductance of 600 mH while the momentary coil current is about 0.75 A, the energy $E(L)$ stored in the inductor is about 170 mJ. For normal switches, the amount of avalanche energy they can resist is about 350 mJ.

[0008] However, it is also possible a user to switch off the lamp 2 by switching the mains. Or, it may be that the lamp fails and stops working. In both cases, the above scenario also takes place, with the difference that the timing with respect to the current phase is now random so it may coincide with the maximum lamp current and thus may result in a very high voltage peak over the switch. In the example mentioned above, the maximum lamp current may be about 1.6 A and the energy applied to the switch is about 770 mJ.

[0009] An object of the present invention is to provide a ballast with an electronic switching circuit wherein the above-mentioned problems are overcome, particularly, wherein the electronic switch is protected against high induction voltage pulses.

[0010] According to the present invention, the controller 28 is adapted to monitor whether a current flows through the switch while it is OFF, and if so, to switch the switch to its ON condition. Now the current, which continues to flow, does not harm the switch any more, and the switch may dissipate some of the energy on the basis of its small resistance R_{DSon} .

[0011] Further advantageous elaborations are mentioned in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] These and other aspects, features and advantages

tages of the present invention will be further explained by the following description of one or more preferred embodiments with reference to the drawings, in which same reference numerals indicate same or similar parts, and in which:

figure 1 is a schematic block diagram illustrating a conventional EM ballast with a mechanical switch;
figure 2 is a schematic block diagram illustrating an EM ballast with a controllable semiconductor switch;
figure 3 is a schematic block diagram illustrating an EM ballast with a controllable semiconductor switch according to the present invention;
figure 4 is a block diagram schematically illustrating a hardware implementation of the present invention;
figure 5 is a flow diagram schematically illustrating a software implementation of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013] Figure 3 is a block diagram schematically illustrating an embodiment of a ballast according to the present invention, generally indicated by the reference numeral 110, having an electronic switching circuit 120, which comprises all elements of the circuit 20 as described above, plus additionally a current sensor 127 in series with the switch 26. The current sensor may be implemented as a small resistance, but it is in this embodiment shown as a diode. The controller 28 has a sense input 28b for receiving the output signal from the current sensor 127.

[0014] Figure 4 is a block diagram schematically illustrating a hardware implementation of the present invention. The controller 28 comprises a comparator 41, having its positive input connected to the sense input 28b and receiving a reference voltage U_{ref} at its negative input. The controller 28 further comprises an AND gate 42, having one input connected to the output of the comparator 41, and receiving an enable signal Se at another input. The controller 28 further comprises an OR gate 43, having one input connected to the output of the AND gate 42, and receiving a control signal Sc at another input.

[0015] During the stages of preheating and ignition, the enable signal Se is LOW, and the output signal from the AND gate 42 is LOW. Thus, the switching state of the switch 26 is only determined by the control signal Sc , which is HIGH for closing the switch 26 to generate the preheat current and which is switched to LOW for opening the switch to trigger ignition.

[0016] Then, the controller 28 enters a normal operation mode, during which the lamp is burning normally. In this mode, the enable signal Se is HIGH and the control signal Sc is LOW. As long as no current is flowing through the switch 26, the output signal from the AND gate 42 remains LOW and the switch remains open. As soon as a current in the switch 26 (which must be an avalanche current because the switch is open) reaches a sufficient magnitude, the comparator 41 outputs a HIGH signal,

causing the AND gate 42 to output a HIGH signal, which in turn causes the OR gate 43 to output a HIGH signal so that the switch 26 is closed. Note that the switch 26 is opened automatically when the current in the switch has extinguished.

[0017] Figure 5 is a flow diagram schematically illustrating a software implementation of the present invention.

[0018] In step 51, the controller 28 checks whether it is operating in a mode in which current through the switch is allowed, such as the preheat phase or ignition. If yes, no further action needs to be taken.

[0019] In step 52, the controller 28 checks whether any current is flowing through the switch. If no, the controller 28 sets or maintains a control signal for the switch 26 such as to turn or maintain the switch OFF in step 53a. If yes, the controller 28 sets or maintains a control signal for the switch 26 such as to turn or maintain the switch ON in step 53b.

[0020] It is noted that in the above embodiments the rectifier 21 allows the use of relatively cheap MOSFETs, which should be operated to conduct current in one direction only. Instead, it is in principle possible to another type of controllable switch, capable to be operated with current in two directions, in which case the rectifier can be omitted.

[0021] Summarizing, the present invention provides an electro magnetic ballast 110 for a gas discharge lamp 2, which comprises:

- input terminals 3, for receiving a mains voltage;
- lamp connector terminals 4, for receiving a lamp;
- a controllable semiconductor switch 26 coupled in parallel to the lamp connector terminals;
- a current sensor 127 connected in series with the controllable switch 26;
- and a control circuit 28 for controlling the controllable switch 26 and responsive to the current sensor 127.

[0022] When operating in a normal mode, the control circuit 28 is responsive to a current sense signal received from the current sensor to switch the controllable switch 26 ON if said current sense signal indicates a current flowing in the controllable switch 26 and to switch the controllable switch 26 OFF if said current sense signal indicates that no current is flowing in the controllable switch 26.

[0023] While the invention has been illustrated and described in detail in the drawings and foregoing description, it should be clear to a person skilled in the art that such illustration and description are to be considered illustrative or exemplary and not restrictive. The invention is not limited to the disclosed embodiments; rather, several variations and modifications are possible within the protective scope of the invention as defined in the appended claims. For instance, the capacitor C may be absent. Further, the inventive gist of the present invention can also be applied to protect other semiconductor

switches against avalanche currents, i.e. even in other applications not being a lamp ballast application.

[0024] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope.

[0025] In the above, the present invention has been explained with reference to block diagrams, which illustrate functional blocks of the device according to the present invention. It is to be understood that one or more of these functional blocks may be implemented in hardware, where the function of such functional block is performed by individual hardware components, but it is also possible that one or more of these functional blocks are implemented in software, so that the function of such functional block is performed by one or more program lines of a computer program or a programmable device such as a microprocessor, microcontroller, digital signal processor, etc.

Claims

1. An electromagnetic ballast (110) for a gas discharge lamp (2), comprising:

- input terminals (3), for receiving a mains voltage;
- lamp connector terminals (4), for receiving a lamp;
- a controllable semiconductor switch (26) coupled in parallel to the lamp connector terminals;
- a current sensor (127) connected in series with the controllable switch (26); and
- a control circuit (28) for controlling the controllable switch (26) and responsive to the current sensor (127);

wherein, when operating in a normal mode and while the controllable semiconductor switch (26) is OFF, the control circuit (28) is responsive to a current sense signal received from the current sensor to switch the controllable switch (26) ON if said current

sense signal indicates a current flowing in the controllable switch (26) and to switch the controllable switch (26) OFF if said current sense signal indicates that no current is flowing in the controllable switch (26).

2. Electromagnetic ballast according to claim 1, comprising:

- an impedance connected in series with the lamp connector terminals, the impedance comprising at least an inductor (L) and preferably comprising a series arrangement of a capacitor (C) and an inductor (L);
- an electronic switching circuit (120) having input terminals (22, 23) connected 20 in parallel to the lamp connector terminals;

wherein the electronic switching circuit (120) comprises:

- the controllable switch (26) coupled in parallel to the input terminals (22, 23);
- and the control circuit (28) having an output (28a) coupled to a control input of the controllable switch (26) and having a sense input (28b) coupled to an output of the current sensor (127);

wherein the control circuit (28) is capable of operating in a preheat mode in which it generates a first control signal for the controllable switch (26) such as to render the controllable switch (26) conductive; wherein the control circuit (28) is capable of operating in an ignition mode after said preheat mode in which it generates a second control signal for the controllable switch (26) such as to render the controllable switch (26) non-conductive; and wherein the control circuit (28) is capable of operating in a normal mode in which a lamp current is flowing and the control circuit (28) normally maintains its second control signal for the controllable switch (26) such as to keep the controllable switch (26) non-conductive; and wherein the control circuit (28), while operating in said normal mode, is responsive to the current sense signal received at its sense input (28b) to generate its first control signal for the controllable switch (26) if said current sense signal indicates a current flowing in the controllable switch (26) and to generate its second control signal for the controllable switch (26) if said current sense signal indicates that no current is flowing in the controllable switch (26).

3. Electro magnetic ballast according to claim 2, wherein the electronic switching circuit comprises a rectifier (21) connected to the input terminals (22, 23) and having a positive output terminal (24) and a negative output terminal (25);

wherein the series arrangement of said controllable switch (26) and said current sensor (127) is connected between said positive output terminal (24) and said negative output terminal (25).

4. Method for protecting a controllable semiconductor switch (26) against avalanche currents, the method comprising the steps of:

while the semiconductor switch (26) is OFF, sensing the current through the semiconductor switch (26) in the forward direction;
if the sensed current is above a predetermined threshold, generating a control signal for the semiconductor switch (26) such as to turn the semiconductor switch (26) ON.

Patentansprüche

1. Elektromagnetisches Vorschaltgerät (110) für eine Gasentladungslampe (2), mit:

- Eingangsanschlüssen (3) zur Aufnahme einer Netzspannung;
- Lampenanschlussklemmen (4) zur Aufnahme einer Lampe;
- einem parallel zu den Lampenanschlussklemmen gekoppelten, regelbaren Halbleiterschalter (26);
- einem in Reihe mit dem regelbaren Schalter (26) geschalteten Stromsensor (127); sowie
- einem Steuerkreis (28), der so eingerichtet ist, dass er den regelbaren Schalter (26) steuert und auf den Stromsensor (127) anspricht;

wobei der Steuerkreis (28), wenn dieser in einem normalen Modus arbeitet und der regelbare Halbleiterschalter (26) ausgeschaltet ist, auf ein von dem Stromsensor empfangenes Strommesssignal anspricht, um den regelbaren Schalter (26) einzuschalten, wenn das Strommesssignal einen in dem regelbaren Schalter (26) fließenden Strom anzeigt, und um den regelbaren Schalter (26) auszuschalten, wenn das Strommesssignal anzeigt, dass kein Strom in dem regelbaren Schalter (26) fließt.

2. Elektromagnetisches Vorschaltgerät nach Anspruch 1 mit:

- einer mit den Lampenanschlussklemmen in Reihe geschalteten Impedanz, wobei die Impedanz zumindest einen Induktor (L) und vorzugsweise eine Reihenschaltung aus einem Kondensator (C) und einem Induktor (L) umfasst;
- einem elektronischen Schaltkreis (120) mit parallel zu den Lampenanschlussklemmen geschalteten Eingangsanschlüssen (22, 23);

wobei der elektronische Schaltkreis (120) umfasst:

- den parallel zu den Eingangsanschlüssen (22, 23) gekoppelten, regelbaren Schalter (26); und
- wobei der Steuerkreis (28) einen mit einem Steuereingang des regelbaren Schalters (26) gekoppelten Ausgang (28a) und einen mit einem Ausgang des Stromsensors (127) gekoppelten Messeingang (28b) umfasst;

wobei der Steuerkreis (28) imstande ist, in einem Vorheizmodus zu arbeiten, in dem er ein erstes Steuersignal für den regelbaren Schalter (26) erzeugt, um den regelbaren Schalter (26) leitend zu machen; wobei der Steuerkreis (28) imstande ist, nach dem Vorheizmodus in einem Zündmodus zu arbeiten, in dem er ein zweites Steuersignal für den regelbaren Schalter (26) erzeugt, um den regelbaren Schalter (26) nicht-leitend zu machen; und

wobei der Steuerkreis (28) imstande ist, in einem normalen Modus zu arbeiten, in dem ein Lampenstrom fließt und der Steuerkreis (28) normalerweise sein zweites Steuersignal für den regelbaren Schalter (26) aufrechterhält, um den regelbaren Schalter (26) nicht-leitend zu halten; und wobei der Steuerkreis (28) während seines Betriebs in dem normalen Modus auf das an seinem Messeingang (28b) empfangene Strommesssignal anspricht, um sein erstes Steuersignal für den regelbaren Schalter (26) zu erzeugen, wenn das Strommesssignal einen in dem regelbaren Schalter (26) fließenden Strom anzeigt, und um sein zweites Steuersignal für den regelbaren Schalter (26) zu erzeugen, wenn das Strommesssignal anzeigt, dass kein Strom in dem regelbaren Schalter (26) fließt.

3. Elektromagnetisches Vorschaltgerät nach Anspruch 2, wobei der elektronische Schaltkreis einen Gleichrichter (21) umfasst, der mit den Eingangsanschlüssen (22, 23) verbunden ist und einen positiven Ausgangsanschluss (24) sowie einen negativen Ausgangsanschluss (25) aufweist;

wobei die Reihenschaltung aus dem regelbaren Schalter (26) und dem Stromsensor (127) zwischen dem positiven Ausgangsanschluss (24) und dem negativen Ausgangsanschluss (25) geschaltet ist.

4. Verfahren, um einen regelbaren Halbleiterschalter (26) gegen Lawinenströme zu schützen, wobei das Verfahren die folgenden Schritte umfasst, wonach:

der Strom durch den Halbleiterschalter (26) in der Durchlassrichtung abgetastet wird, während der Halbleiterschalter (26) ausgeschaltet ist; wenn der Abtaststrom oberhalb eines vorgegebenen Grenzwertes liegt, ein Steuersignal für den Halbleiterschalter (26) erzeugt wird, um den Halbleiterschalter (26) einzuschalten.

Revendications

1. Ballast électromagnétique (110) pour une lampe à décharge de gaz (2), comprenant :

- des bornes d'entrée (3), pour recevoir une tension de secteur ;
- des bornes de connexion de lampe (4), pour recevoir une lampe ;
- un commutateur semi-conducteur pouvant être commandé (26) couplé en parallèle aux bornes de connexion de lampe ;
- un capteur de courant (127) connecté en série avec le commutateur pouvant être commandé (26) ; et
- un circuit de commande (28) pour commander le commutateur pouvant être commandé (26) et répondant au capteur de courant (127) ;

dans lequel, lors du fonctionnement dans un mode normal et lorsque le commutateur semi-conducteur pouvant être commandé (26) est éteint, le circuit de commande (28) répond à un signal de détection de courant reçu à partir du capteur de courant pour allumer le commutateur pouvant être commandé (26) si ledit signal de détection de courant indique qu'un courant passe dans le commutateur pouvant être commandé (26) et éteindre le commutateur pouvant être commandé (26) si ledit signal de détection de courant indique qu'aucun courant ne passe dans le commutateur pouvant être commandé (26).

2. Ballast électromagnétique selon la revendication 1, comprenant :

- une impédance connectée en série avec les bornes de connexion de lampe, l'impédance comprenant au moins une bobine d'induction (L) et comprenant de préférence un agencement en série d'un condensateur (C) et d'une bobine d'induction (L) ;
- un circuit de commutation électronique (120) comportant des bornes d'entrée (22, 23) connectées en parallèle aux bornes de connexion de lampe ;

dans lequel le circuit de commutation électronique (120) comprend :

- le commutateur pouvant être commandé (26) couplé en parallèle aux bornes d'entrée (22, 23) ; et
- le circuit de commande (28) comportant une sortie (28a) couplée à une entrée de commande du commutateur pouvant être commandé (26) et comportant une entrée de détection (28b) couplée à une sortie du capteur de courant (127) ;

dans lequel le circuit de commande (28) est capable de fonctionner dans un mode de préchauffage dans lequel il génère un premier signal de commande pour le commutateur pouvant être commandé (26) afin de rendre le commutateur pouvant être commandé (26) conducteur ;

dans lequel le circuit de commande (28) est capable de fonctionner dans un mode d'allumage après ledit mode de préchauffage dans lequel il génère un second signal de commande pour le commutateur pouvant être commandé (26) afin de rendre le commutateur pouvant être commandé (26) non conducteur ; et

dans lequel le circuit de commande (28) est capable de fonctionner dans un mode normal dans lequel un courant de lampe passe et le circuit de commande (28) maintient normalement son second signal de commande pour le commutateur pouvant être commandé (26) afin de garder le commutateur pouvant être commandé (26) non conducteur ; et

dans lequel le circuit de commande (28), lors du fonctionnement dans ledit mode normal, répond au signal de détection de courant reçu à son entrée de détection (28b) pour générer son premier signal de commande pour le commutateur pouvant être commandé (26) si ledit signal de détection de courant indique qu'un courant passe dans le commutateur pouvant être commandé (26) et pour générer son second signal de commande pour le commutateur pouvant être commandé (26) si ledit signal de détection de courant indique qu'aucun courant ne passe dans le commutateur pouvant être commandé (26).

3. Ballast électromagnétique selon la revendication 2, dans lequel le circuit de commutation électronique comprend un redresseur (21) connecté aux bornes d'entrée (22, 23) et comportant une borne de sortie positive (24) et une borne de sortie négative (25) ; dans lequel l'agencement en série dudit commutateur pouvant être commandé (26) et dudit capteur de courant (127) est connecté entre ladite borne de sortie positive (24) et ladite borne de sortie négative (25).

4. Procédé pour protéger un commutateur semi-conducteur pouvant être commandé (26) contre des courant d'avalanche, le procédé comprenant les étapes de :

lorsque le commutateur semi-conducteur (26) est éteint, la détection du courant à travers le commutateur semi-conducteur (26) dans le sens direct ;

si le courant détecté est supérieur à un seuil prédéterminé, la génération d'un signal de commande pour le commutateur semi-conducteur (26) afin d'allumer le commutateur semi-conducteur (26).

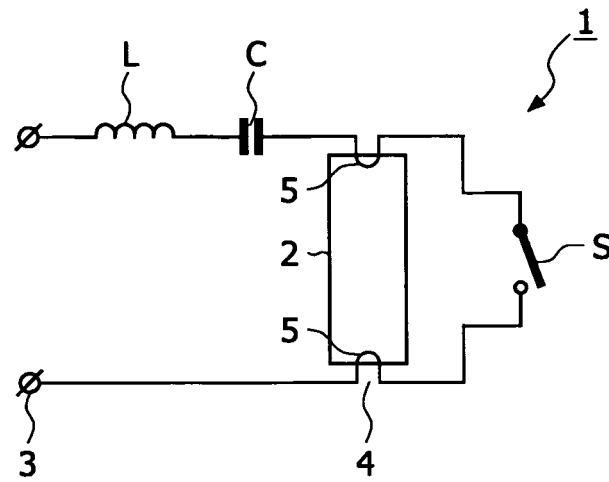


FIG. 1

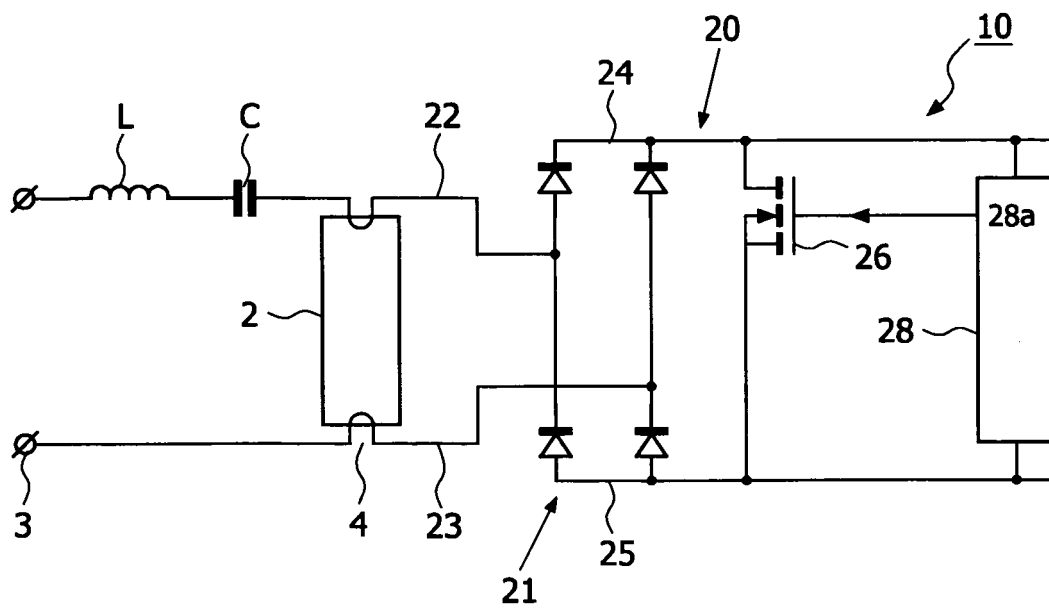


FIG. 2

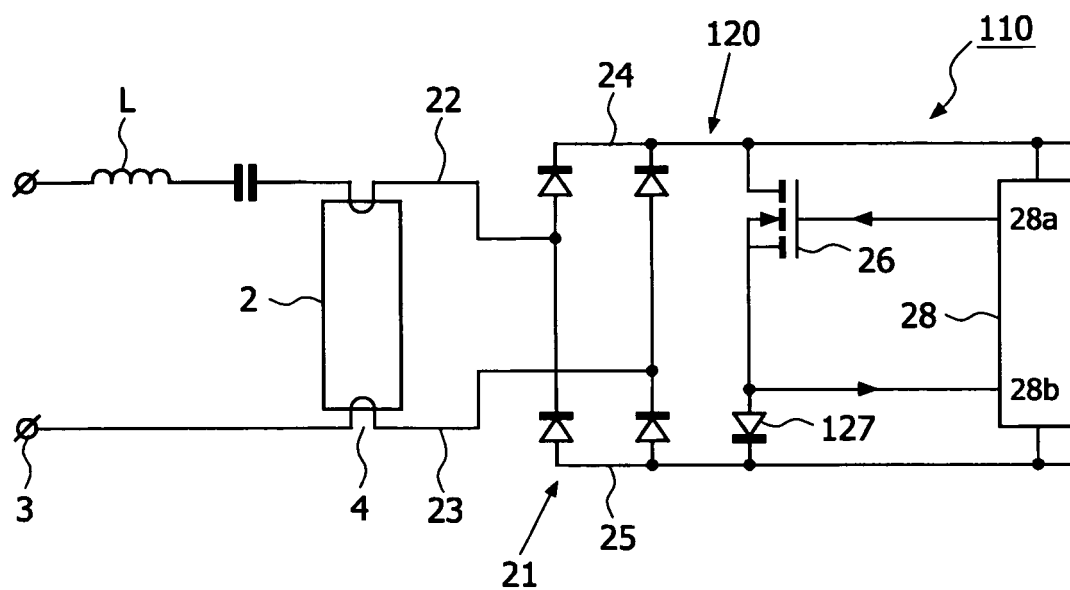


FIG. 3

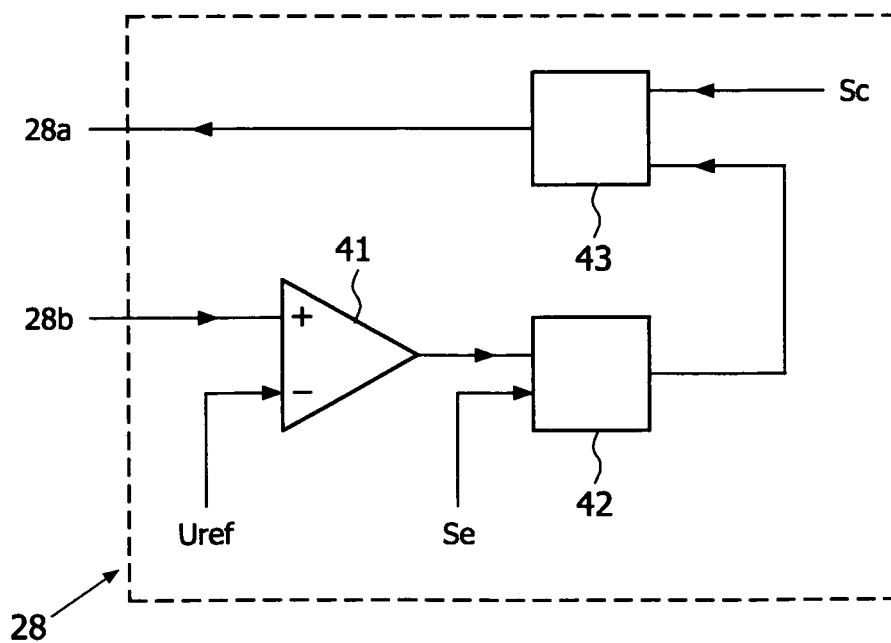


FIG. 4

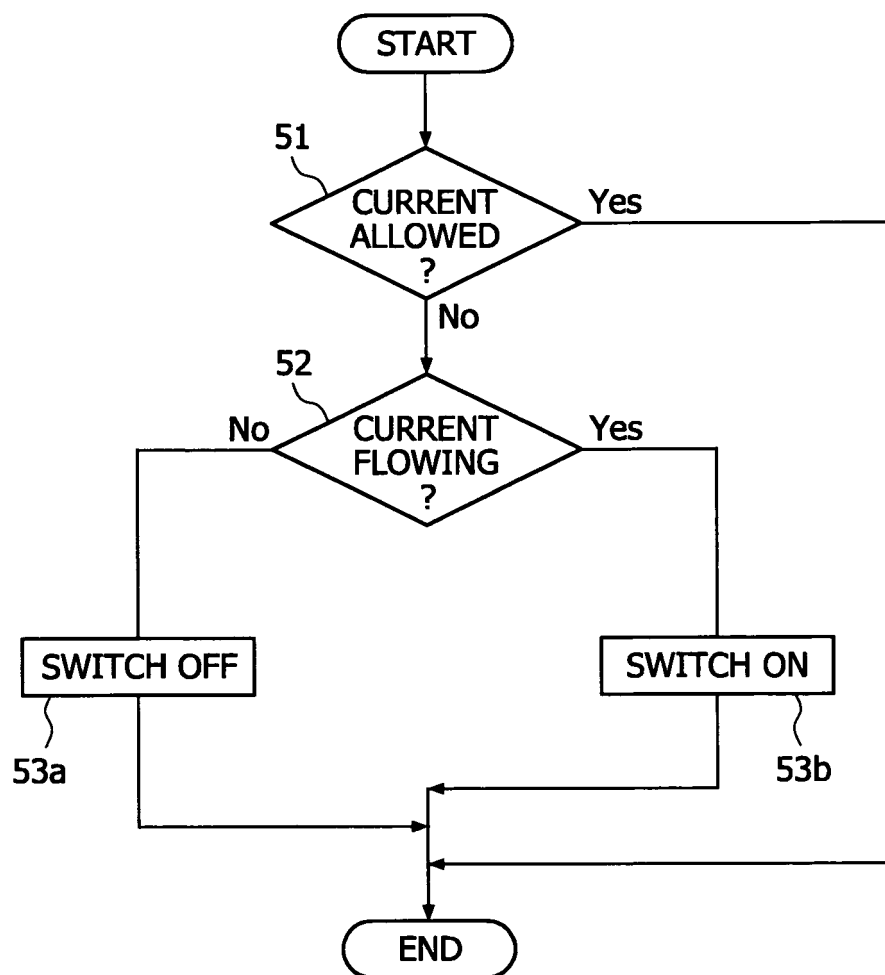


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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